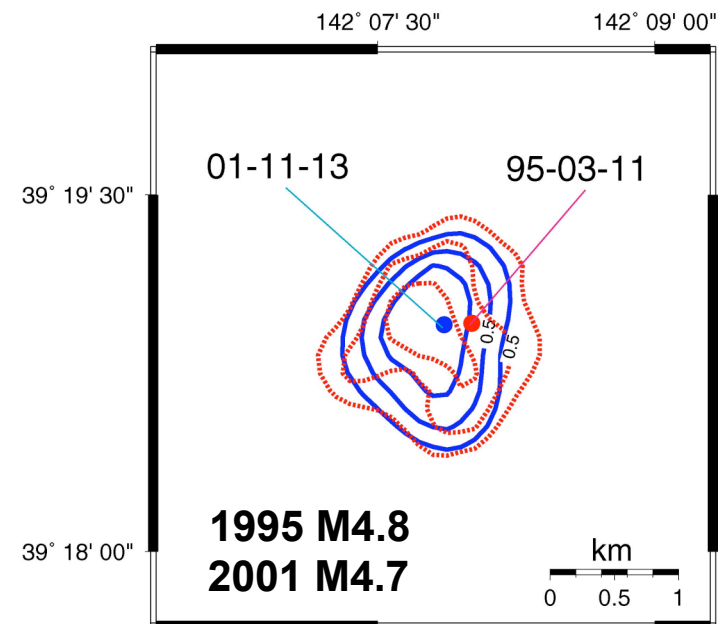
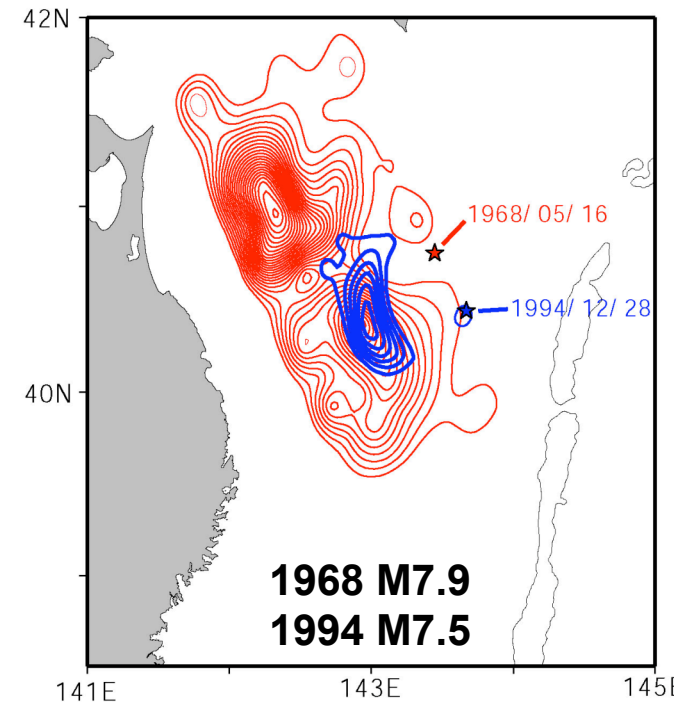


# **An attempt to image earthquake fault plane and asperities by DD tomography for three large shallow inland earthquakes in Japan**

**Akira Hasegawa & Tomomi Okada**

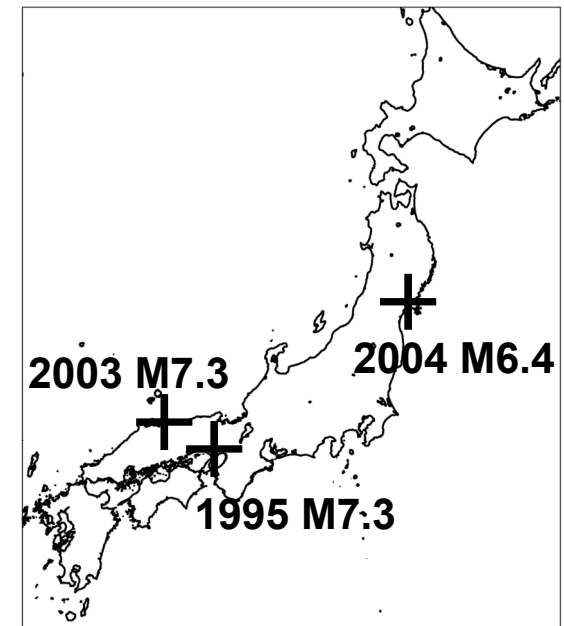
**Research Center for Prediction of Earthquakes  
& Volcanic Eruptions  
Graduate School of Science  
Tohoku University**

- Asperity model seems to be applicable to interplate EQs in Japan
- What is the cause of the asperity?
- Looked into the deep earthquake fault zone by DD seismic tomography (Zhang and Thurber, 2003)
- Applied the method to aftershock data of 3 large EQs obtained by dense temporary seismic networks
- Answer the question:  
 Can we image inhomogeneous velocity structures corresponding to  
 (1) earthquake fault plane and/or  
 (2) asperity ?



- 1995 S. Hyogo (Kobe) EQ (M7.3)  
Okada, T., A. Hasegawa, D. Zhao,  
H. Zhang and C.H. Thurber,  
Imaging the fault plane and asperities of  
inland earthquakes by DD  
tomography(3)

The 1995 S. Hyogo EQ (M7.3), 2004 Fall  
Meeting of SSJ



- 2000 W. Tottori EQ (M7.3)

Okada, T., A. Hasegawa, H. Zhang and C.H. Thurber,  
Detailed seismic velocity structure around the focal area of the  
2000 W. Tottori EQ (M7.3) by DD tomography, 2004 Japan

EPS

Joint Meeting

- 2003 N. Miyagi EQ (M6.4)

Okada, T., A. Hasegawa, J. Suganomata, N. Umino, H. Zhang and  
C.H. Thurber,

Imaging the fault plane and asperities of the 2003 M6.4 N.

Miyagi

EQ, NE Japan, by DD tomography, submittid to EPSL, 2004.

## © 1995 M7.3 Kobe EQ

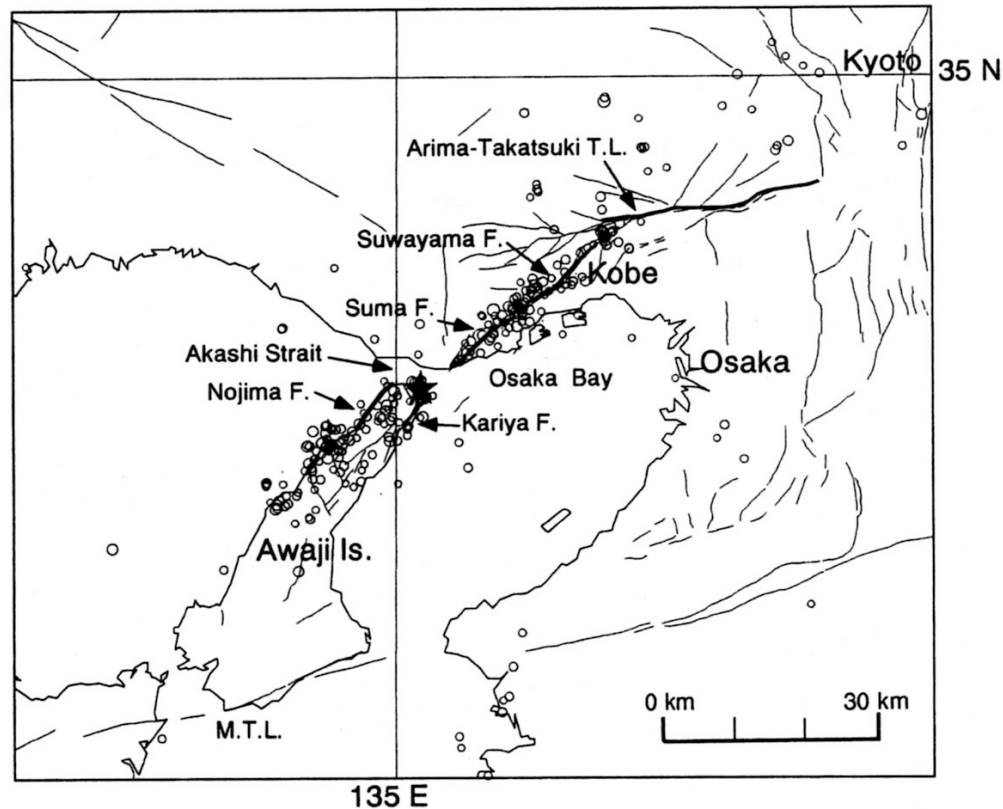


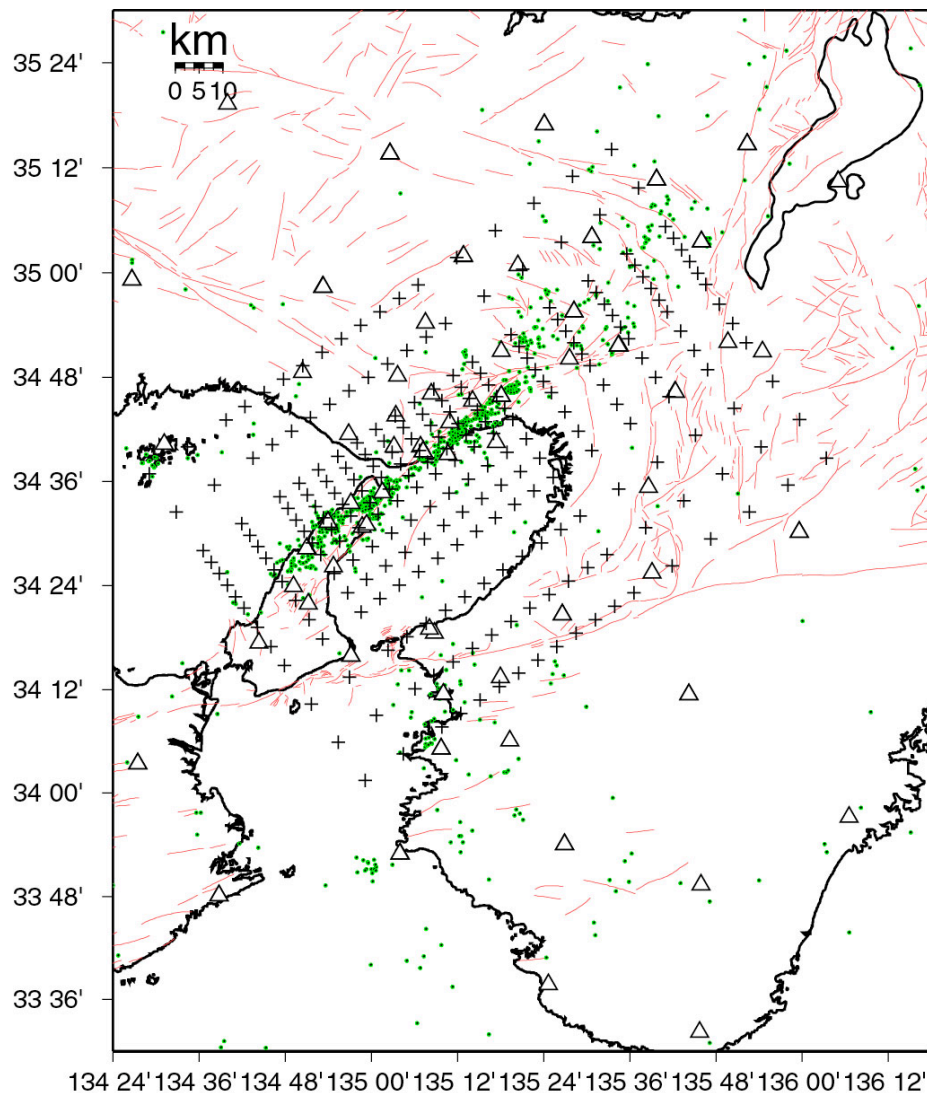
Fig. 2. Index map of the faults and aftershock distribution in the investigated region. The epicenters of the aftershocks with magnitudes greater than 2, which were determined by DPRI, Kyoto University within a month after the occurrence of the main shock, are plotted. The star indicates the epicenter of the main shock.

- Right-lateral strike-slip fault

(Hirata et al., 1996)



# © Locations of stations, EQs & grid points used



stations (triangles)  
events (green dots)  
grids (crosses)

No of events: 915

No of stations:

No of arrival times (P): 23,228

No of arrival times (S): 18,902

No of DD (P): 152,508

No of DD (S): 119,042

grid separation:

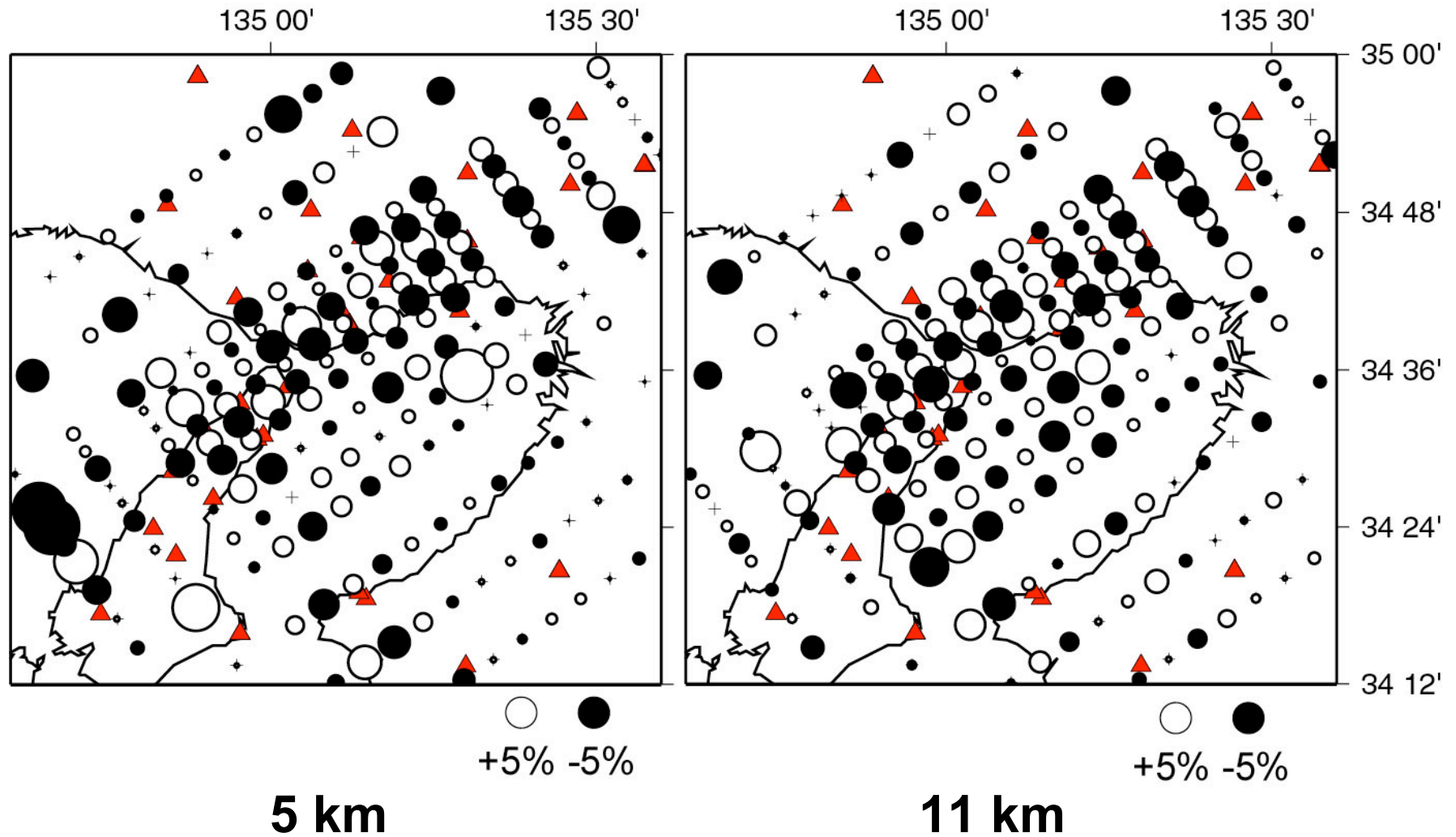
along fault: 5-10 km

across fault: 3-5 km

depth: 3-5 km

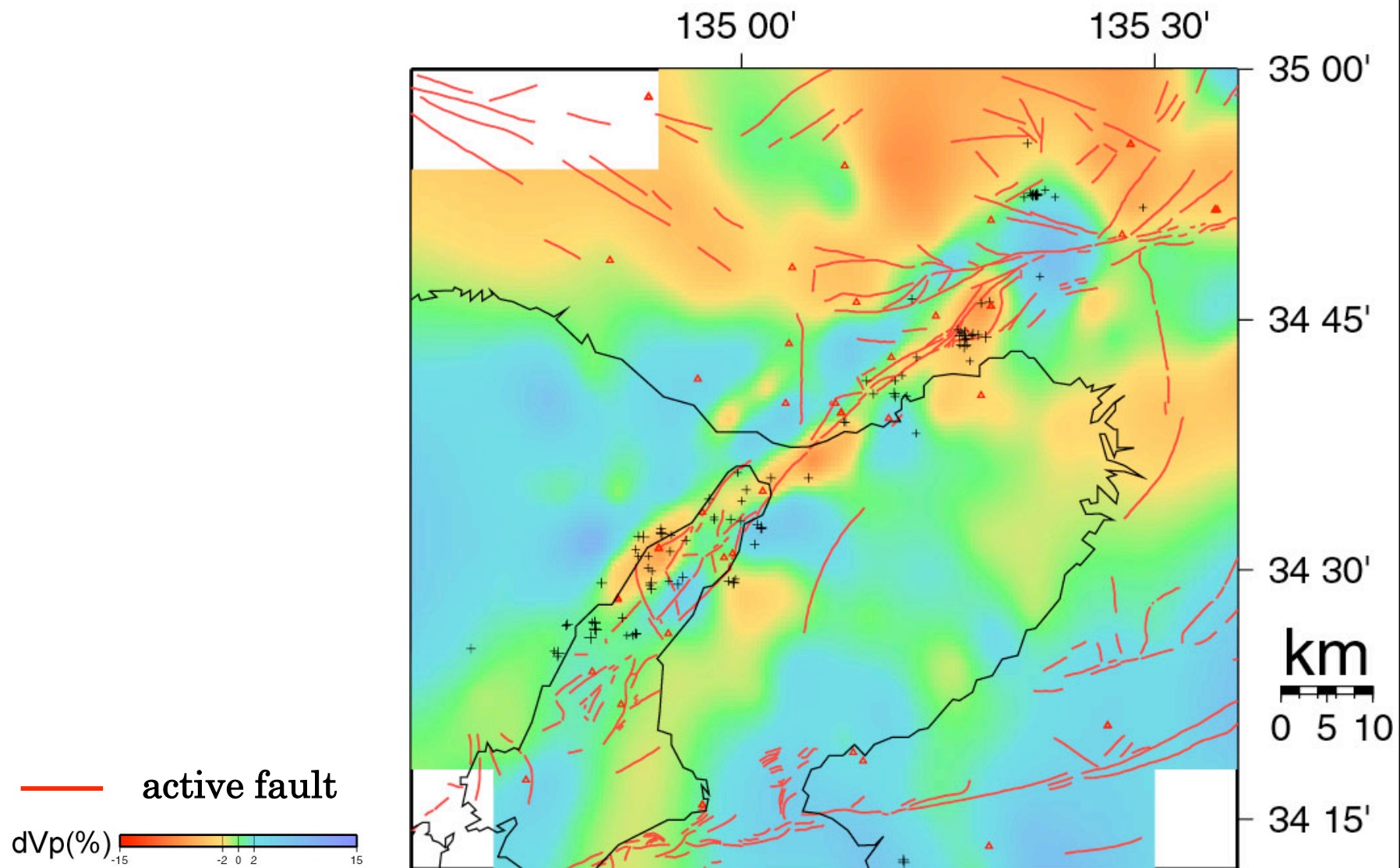
## © Resolution test - dVp

Results of checkerboard resolution test  
dVp at 5 km (left) and at 11 km (right) depths



# © dVp at 5 km depth

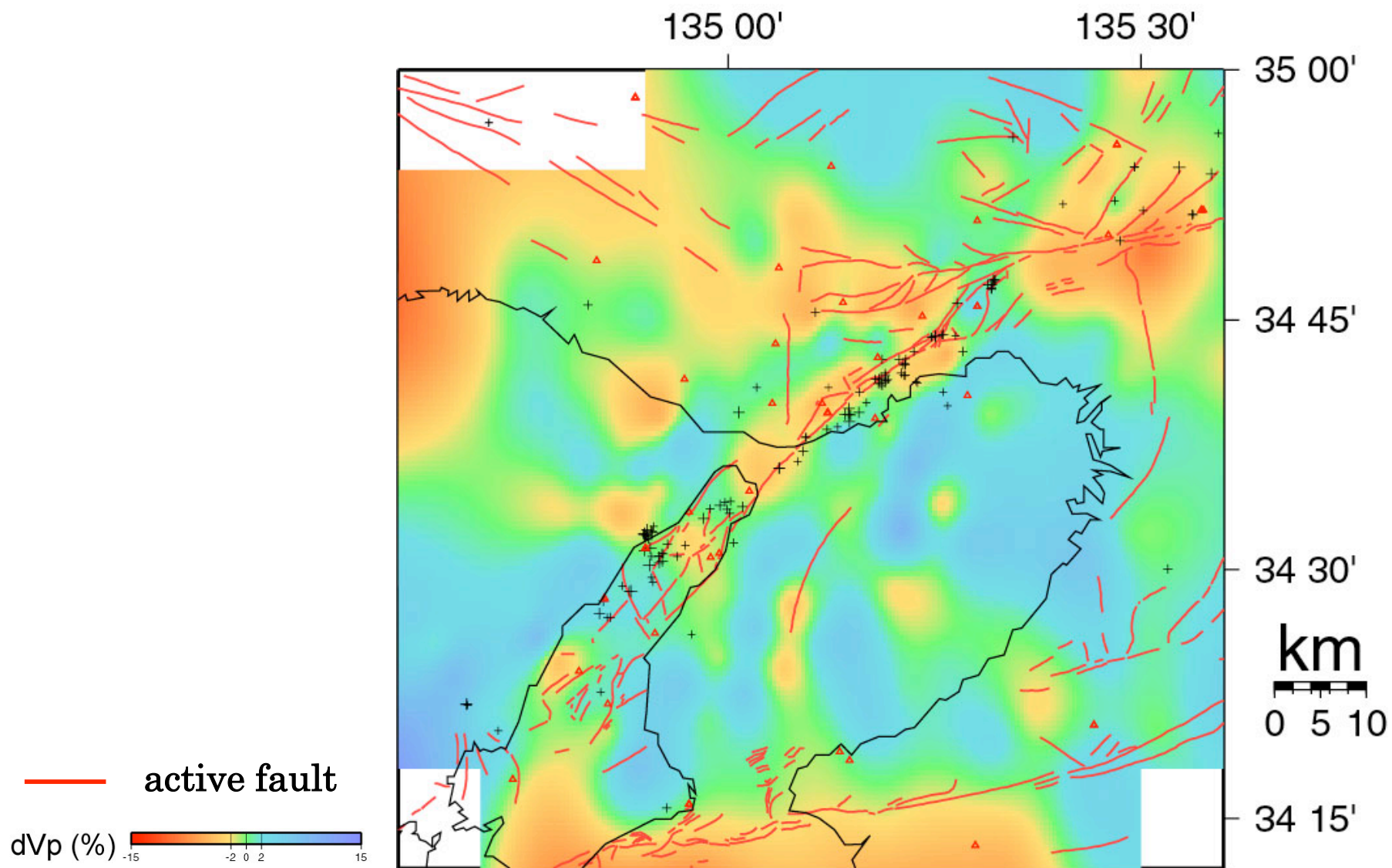
5 km





# © dVp at 11km depth

11 km

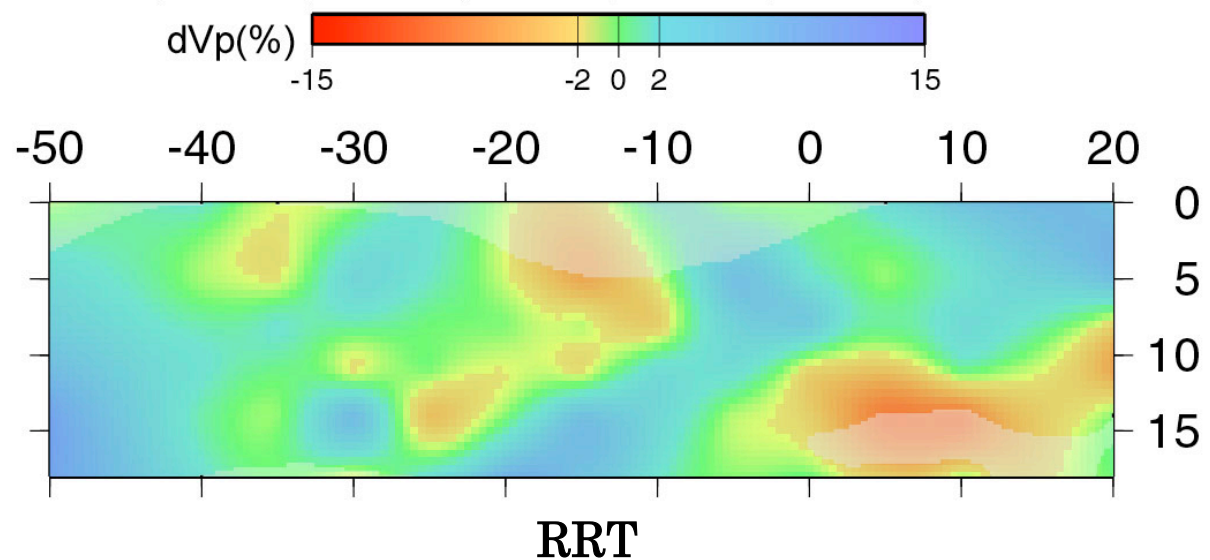
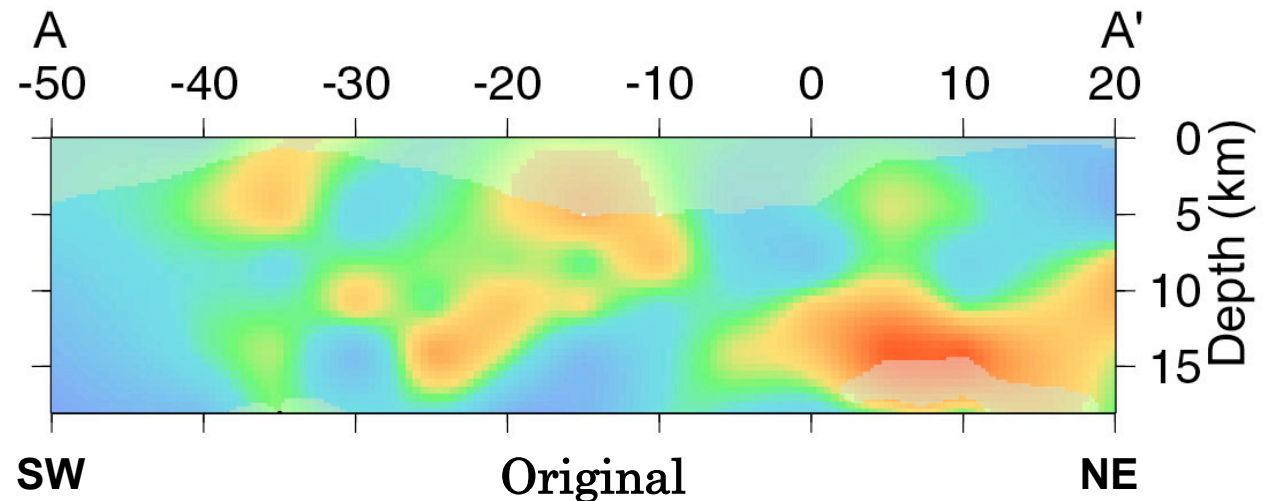


## © Resolution test - dVp

dVp along the fault

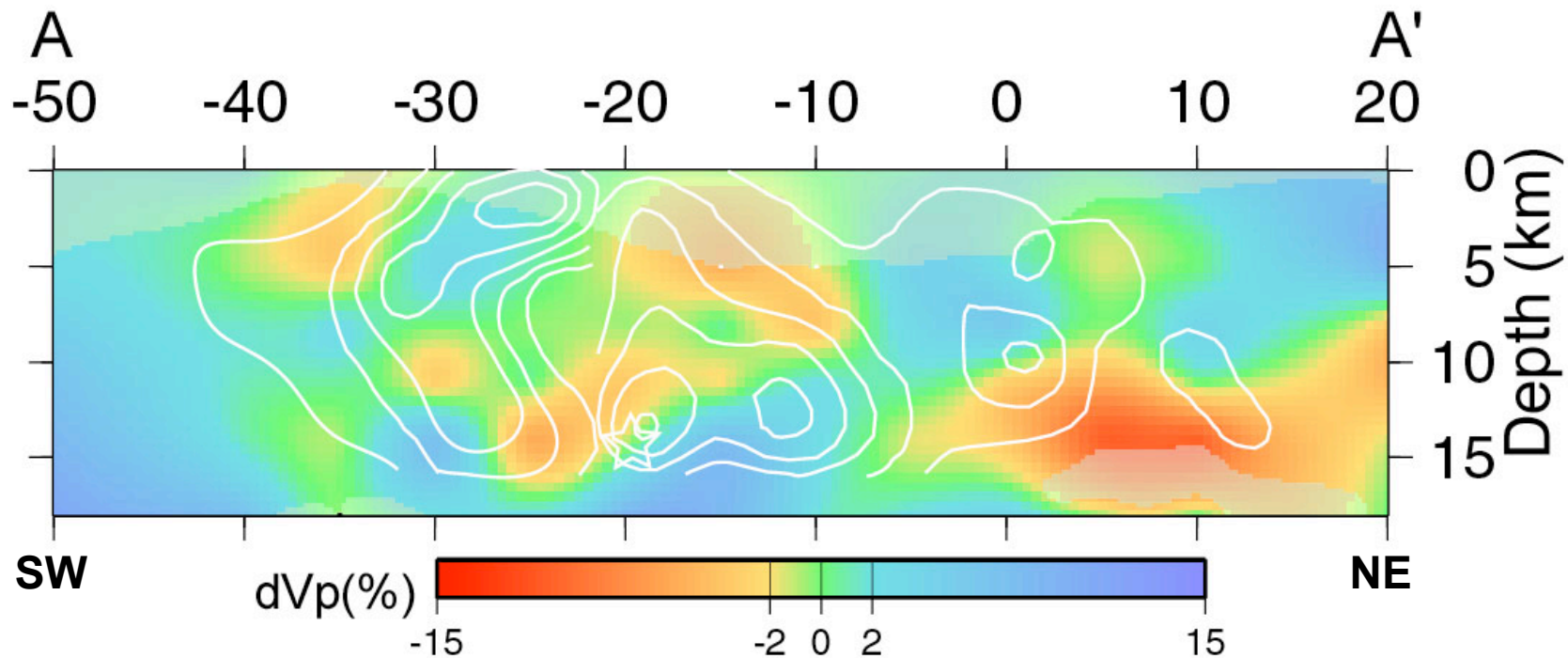
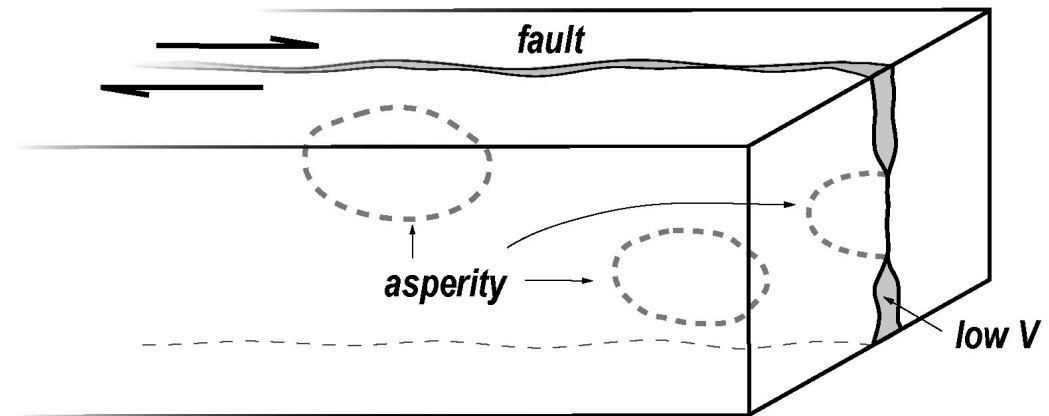
Upper:  
original structure

Lower:  
result of RRT  
(restoring resolution test)

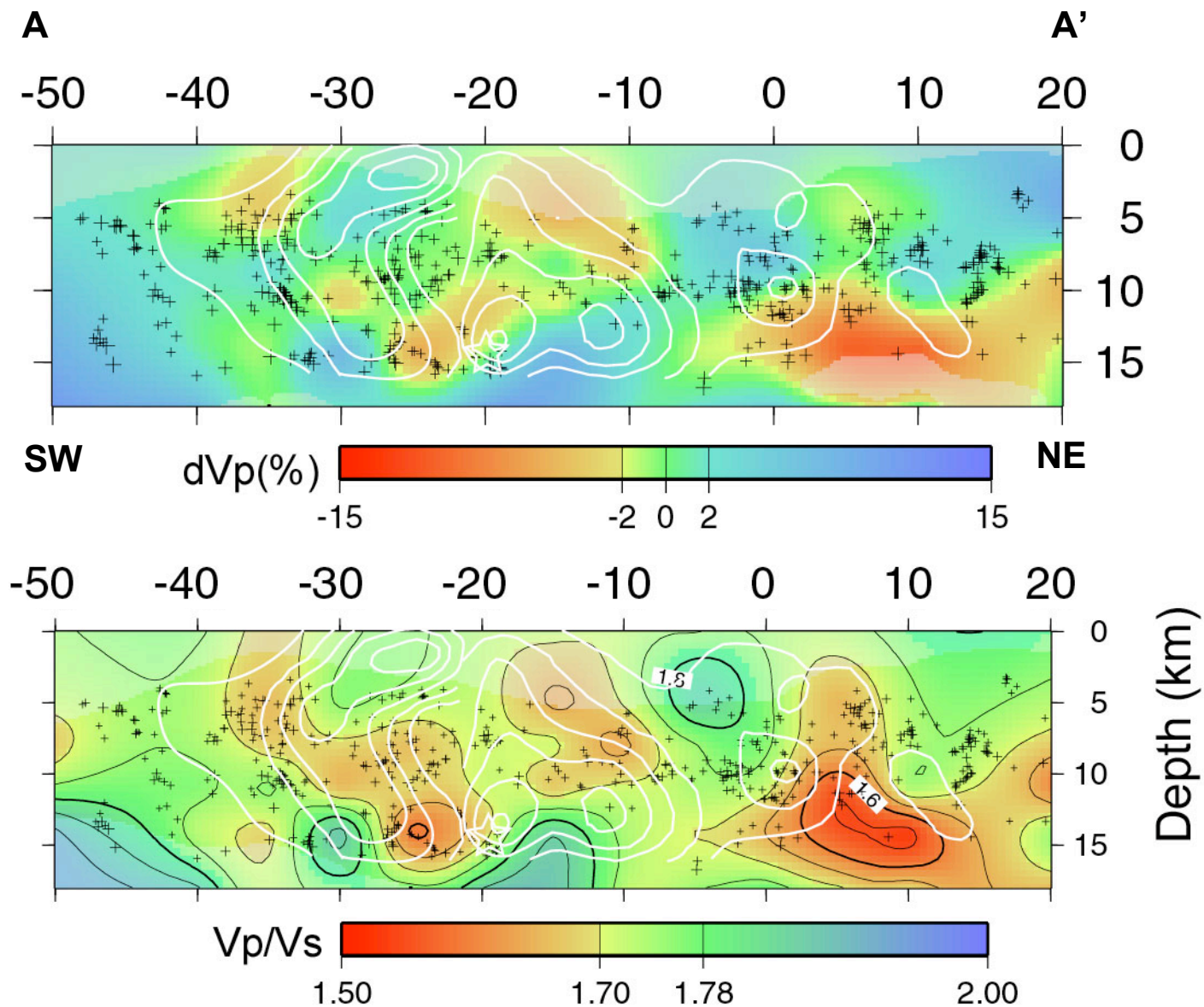


# © dVp & slip distribution along the fault

slip distribution:  
white contours  
(Yoshida et al., 1996)



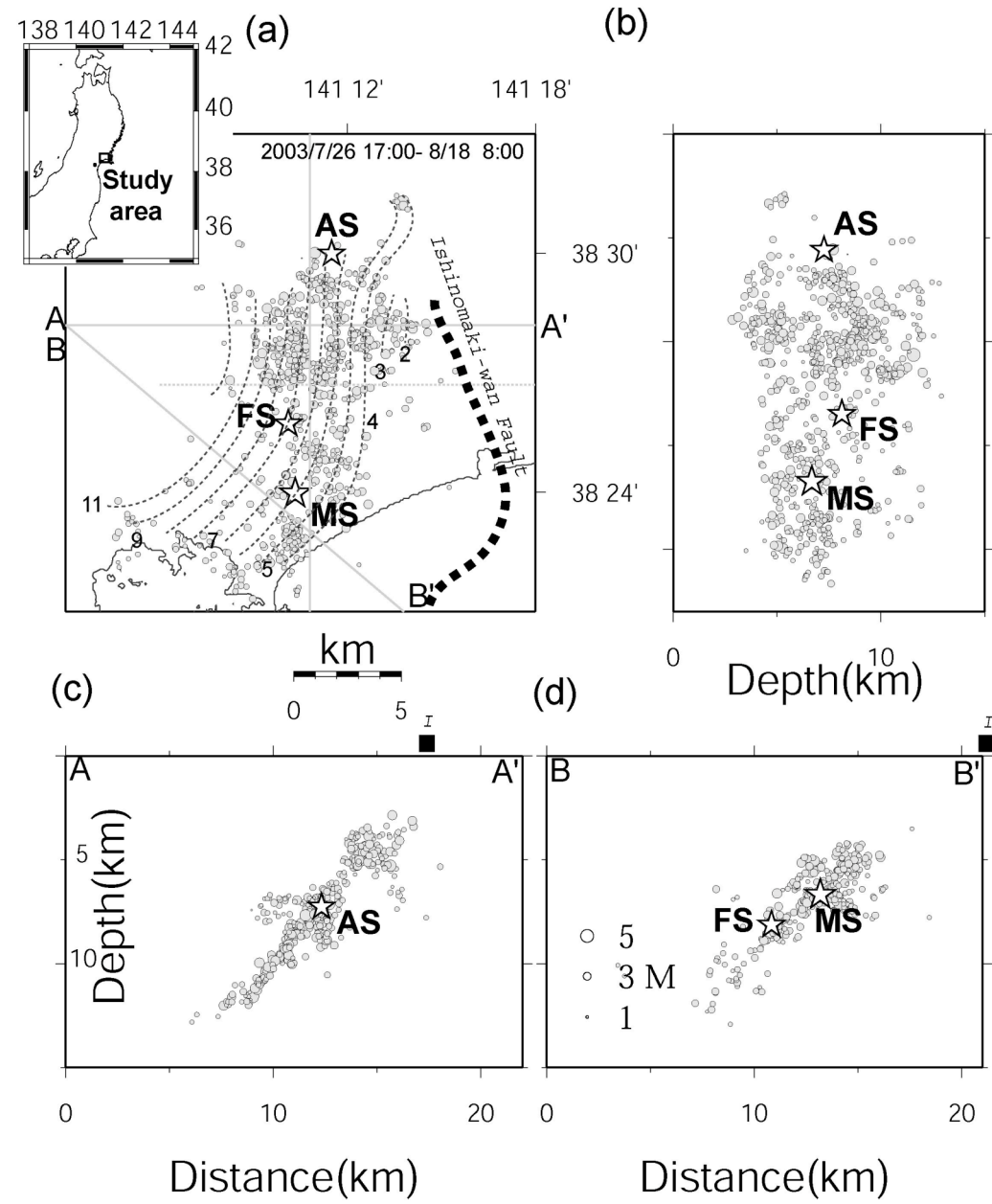
# © dVp, Vp/Vs & slip distribution along the fault





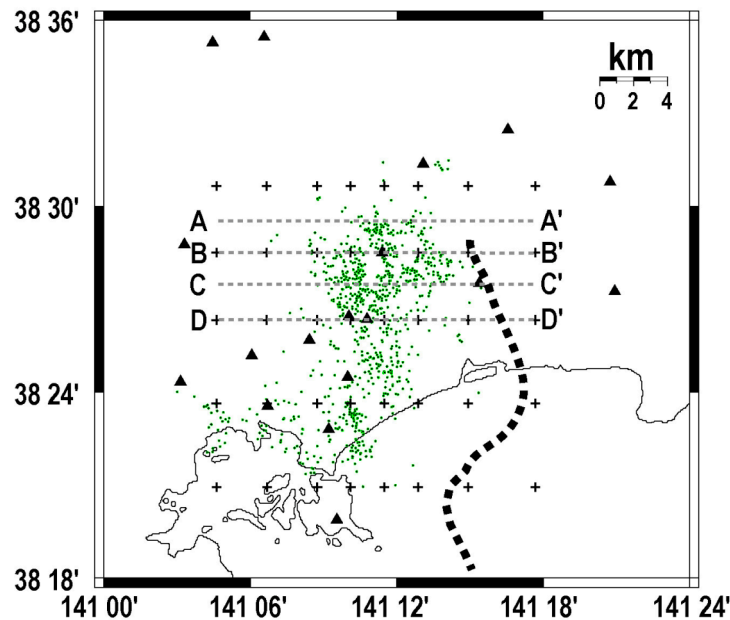
© 2000 M6.4  
N. Miyagi EQ

- reverse fault

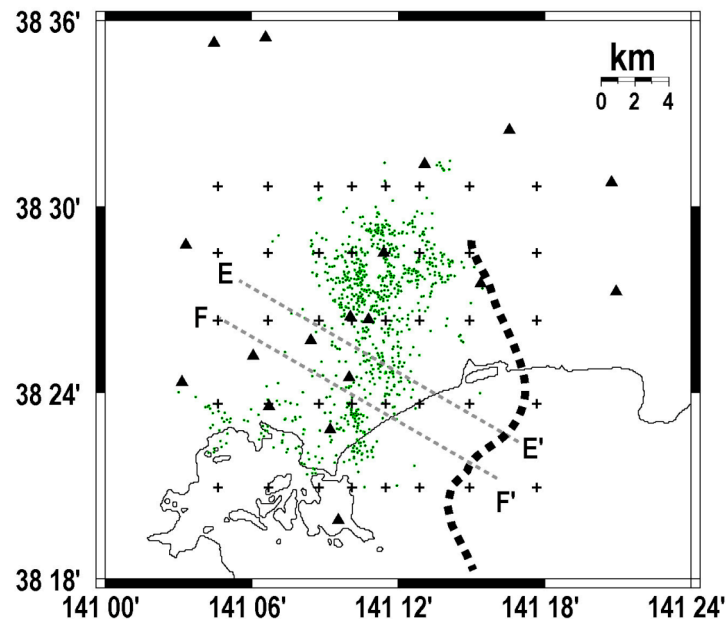




# © Locations of stations, EQs & grid points used



stations (triangles)  
events (green dots)  
grids (crosses)



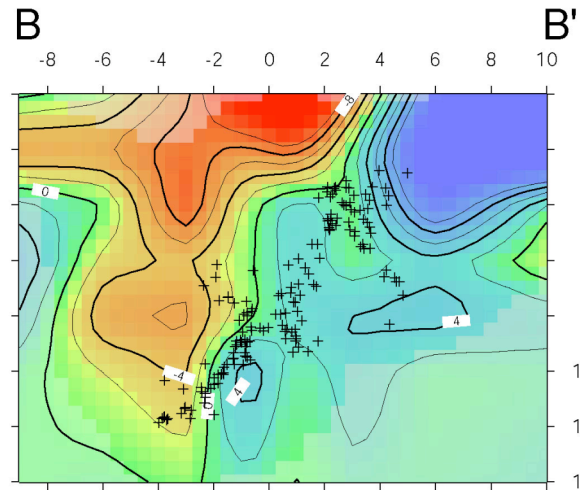
No of events: 853  
No of stations: 18  
No of arrival times (P): 11,893  
No of arrival times (S): 10,154  
No of DD (P): 188,033  
No of DD (S): 143,081  
grid separation:  
EW: 2-3 km  
NS : 4-5 km  
depth: 2-4 km

# © Resolution test

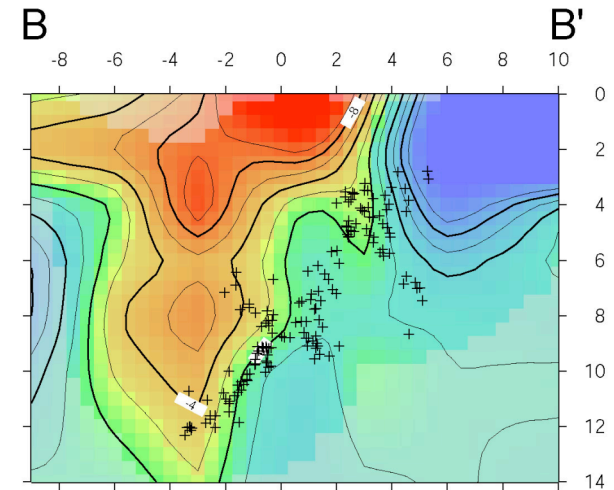
(a) dVp & (b) dVs along BB'

Left: original structure  
Right: result of RRT

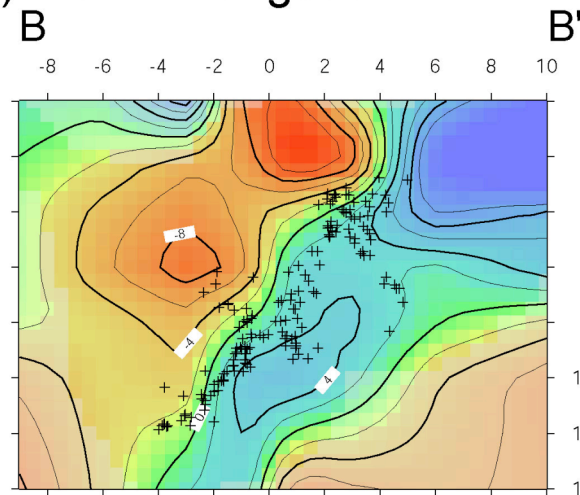
(a) Vp Original



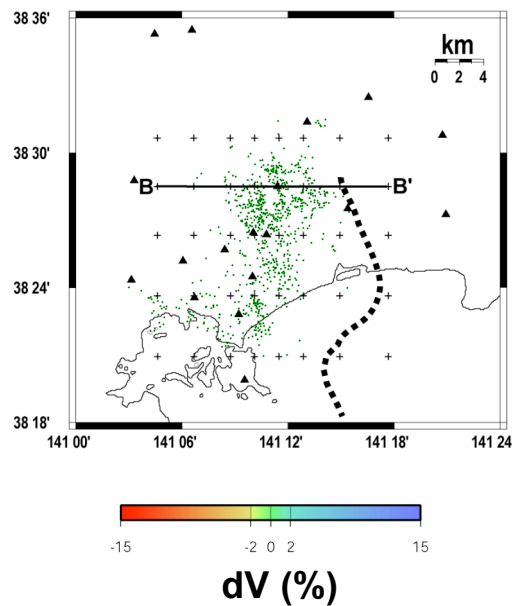
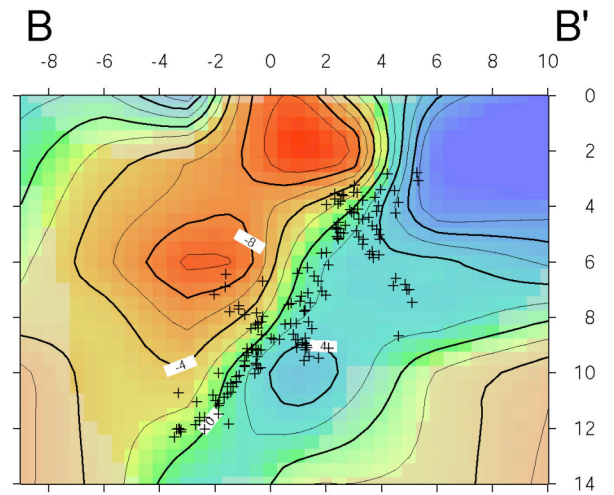
RRT



(b) Vs Original

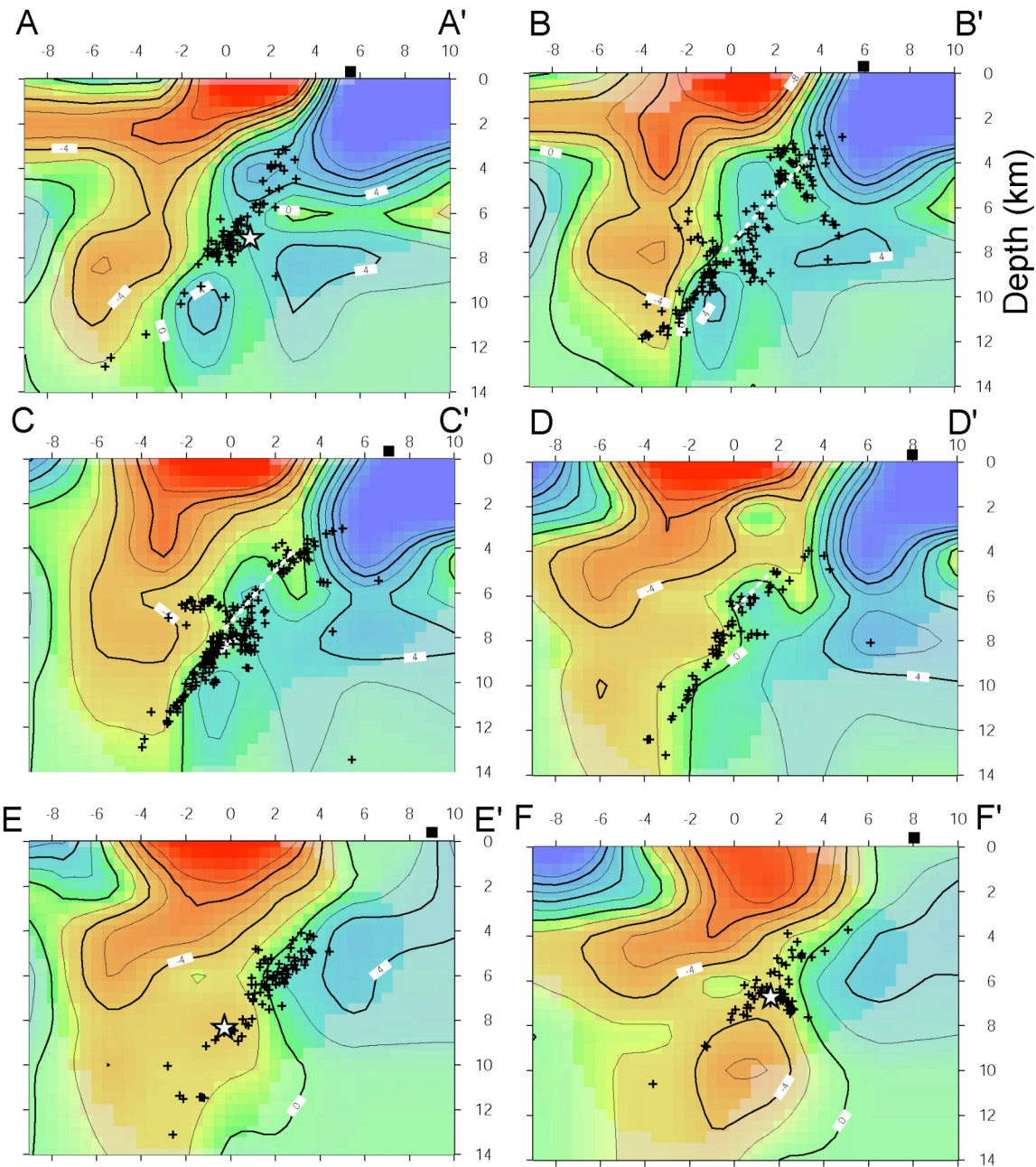
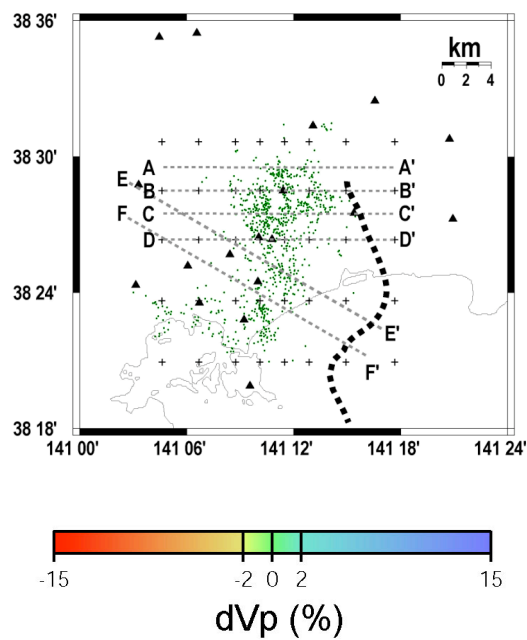


RRT



# © dVp along AA' through FF'

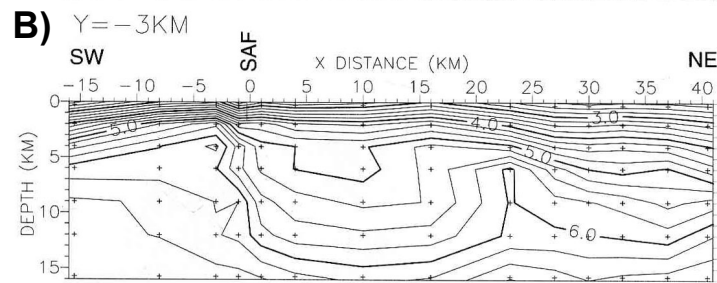
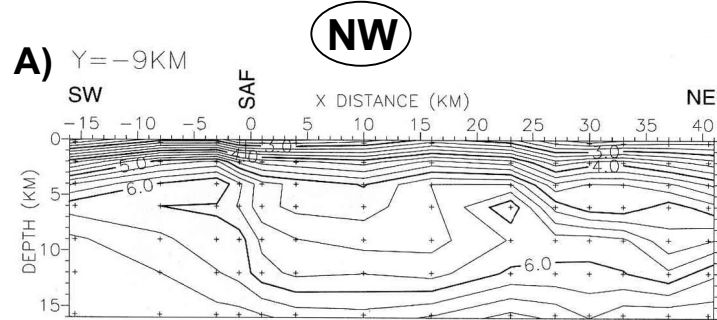
asperity: white broken lines



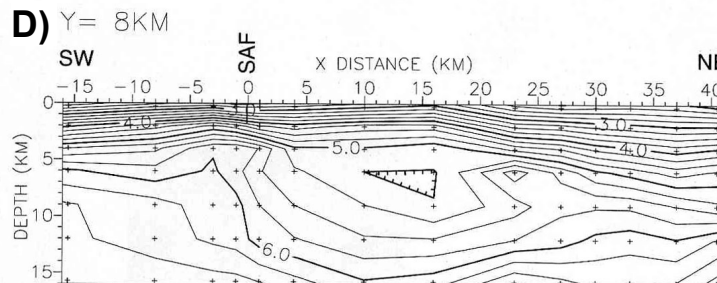
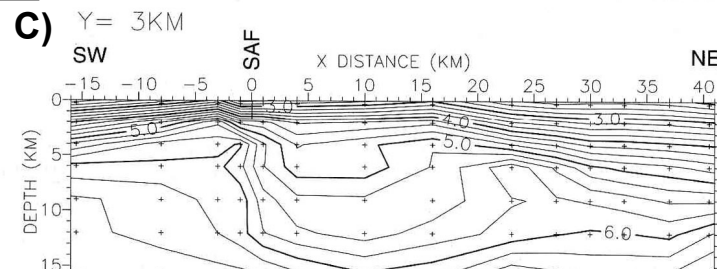


# © Vp in Parkfield region: Across-fault

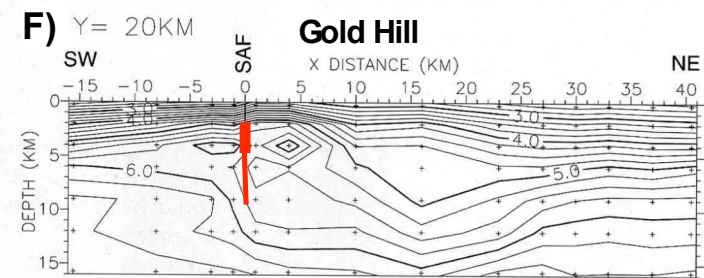
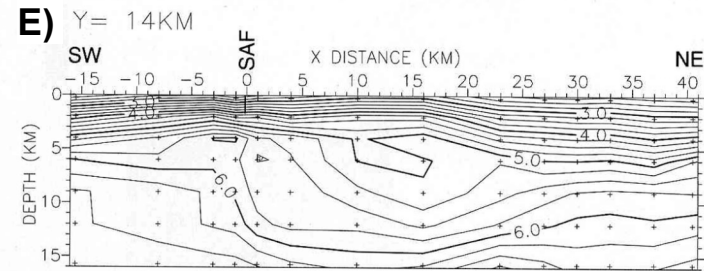
C.S.



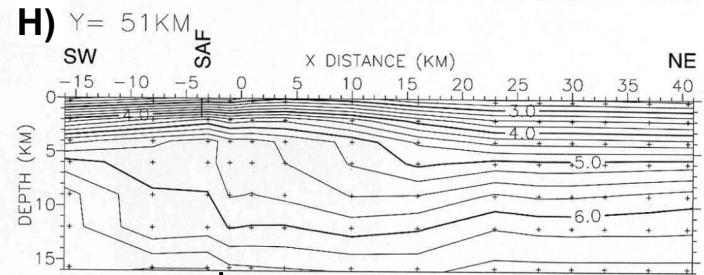
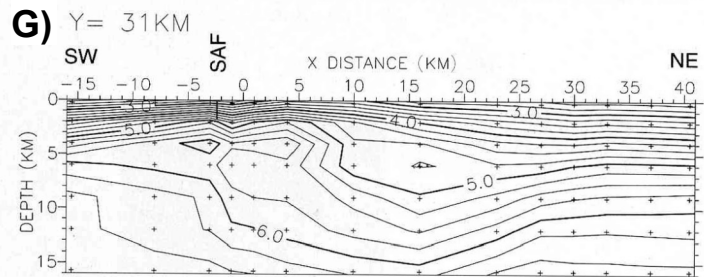
Middle Mountain



high-V ← | → low-V



asperity  
of 1966  
event

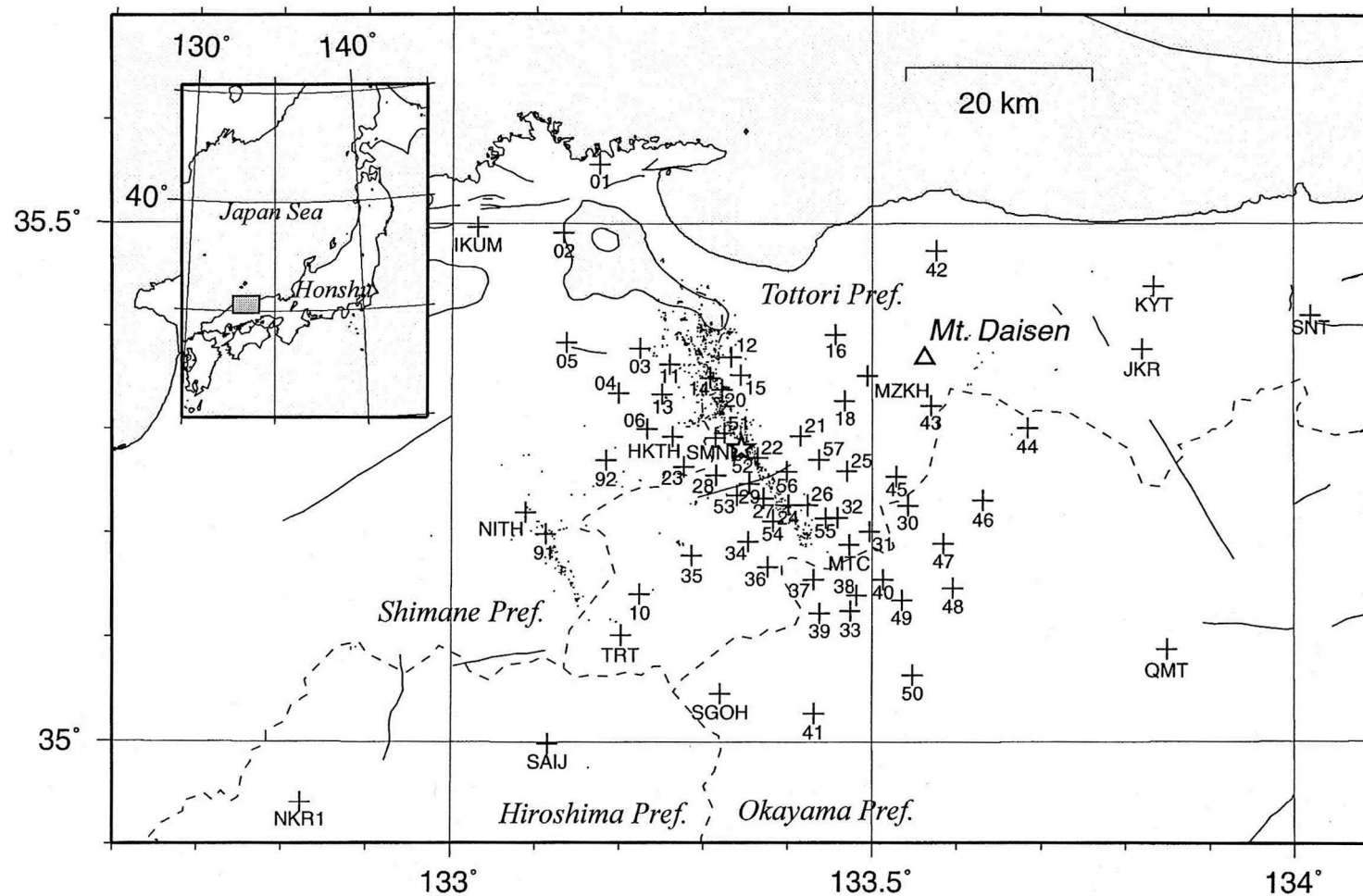


high-V ← | → low-V

SE

(Eberhart-Philips and Michael, 1993)

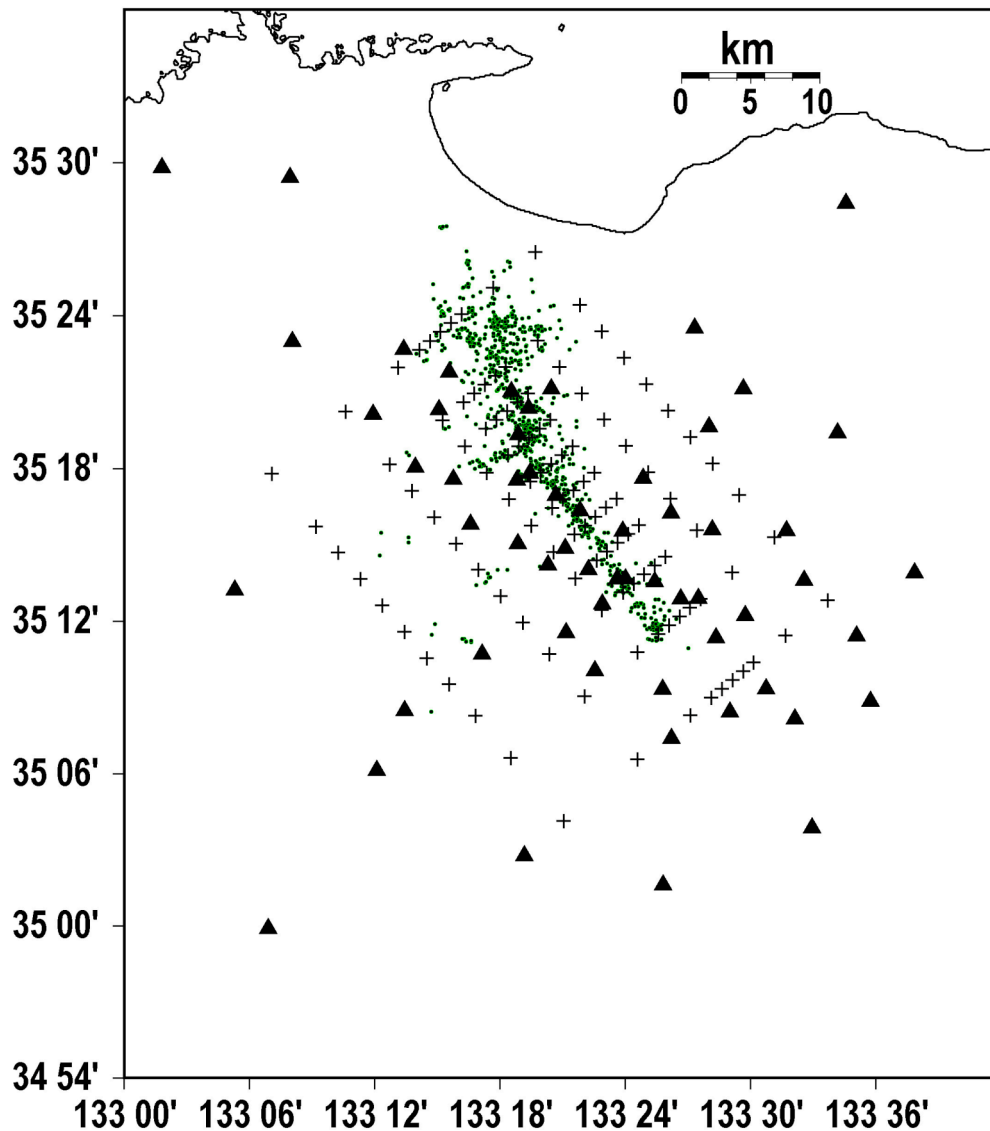
# © 2003 M7.3 W. Tottori EQ



- Left-lateral strike-slip fault

(Shibutani et al., 2004)

## © Locations of stations, EQs & grid points used



stations (triangles)  
events (green dots)  
grids (crosses)

No of events: 960

No of stations: 59

No of arrival times (P): 51,922

No of arrival times (S): 33,840

No of DD (P): 208,166

No of DD (S): 161,382

grid separation:

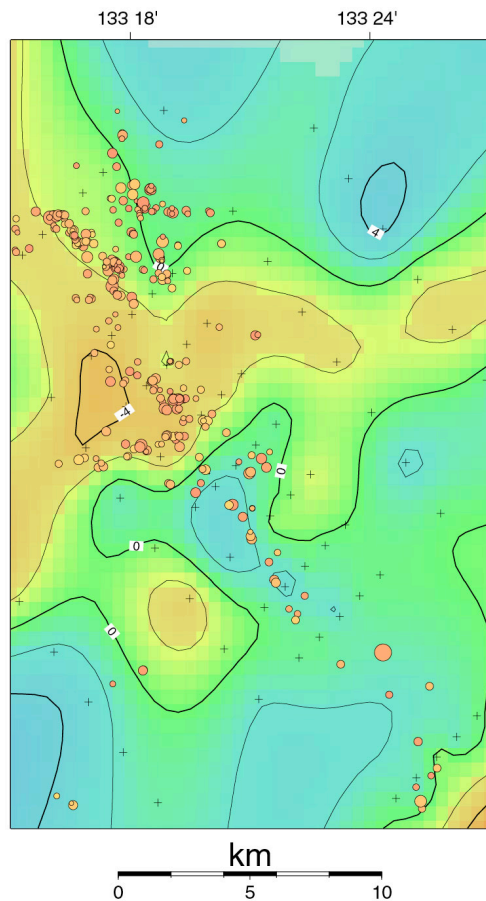
along fault: 2.5-5 km

across fault: 1-7 km

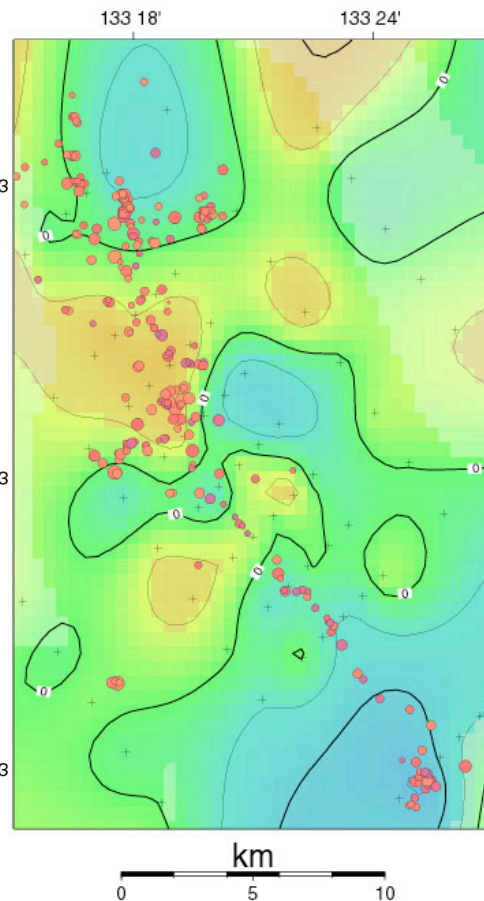
depth: 2-4 km

# © dVp at depths of 4km, 6km & 8 km

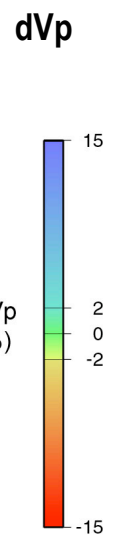
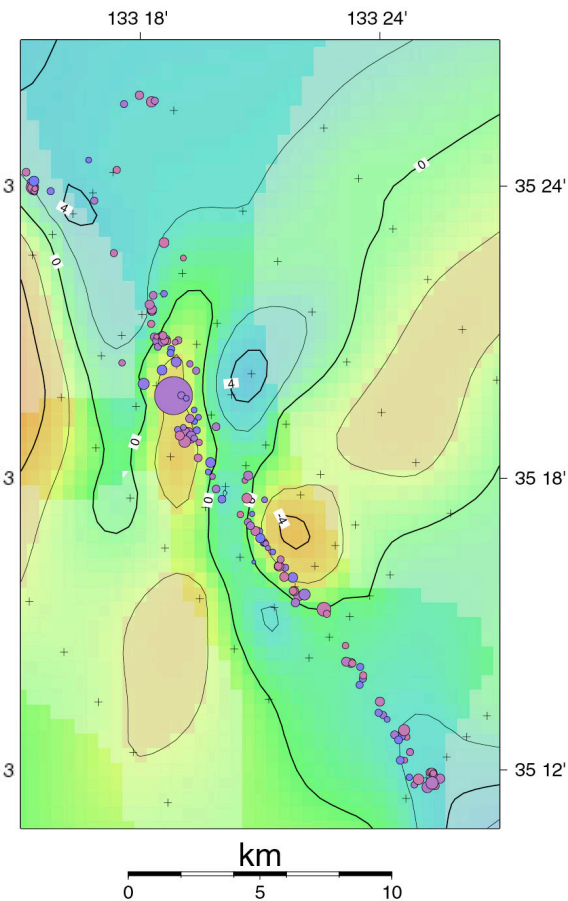
a) 4km



b) 6km



c) 8km





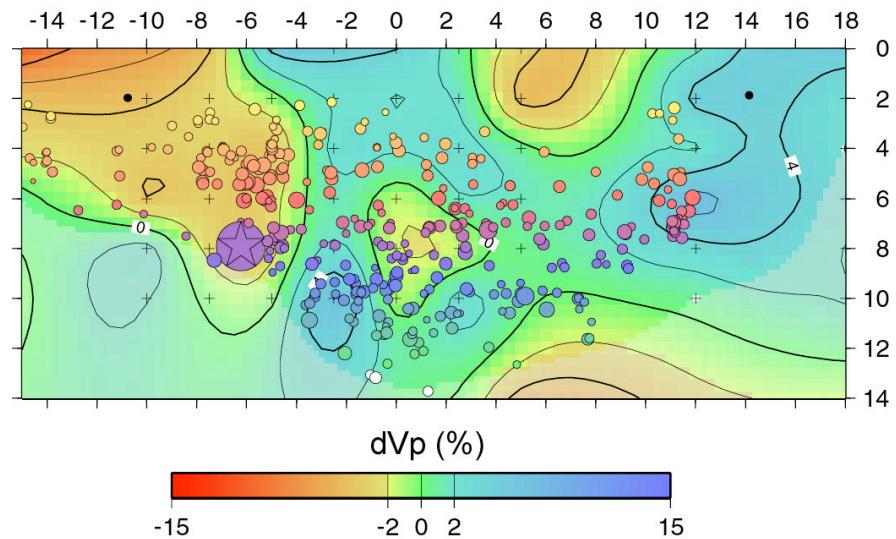
## © Resolution test

dVp along the fault

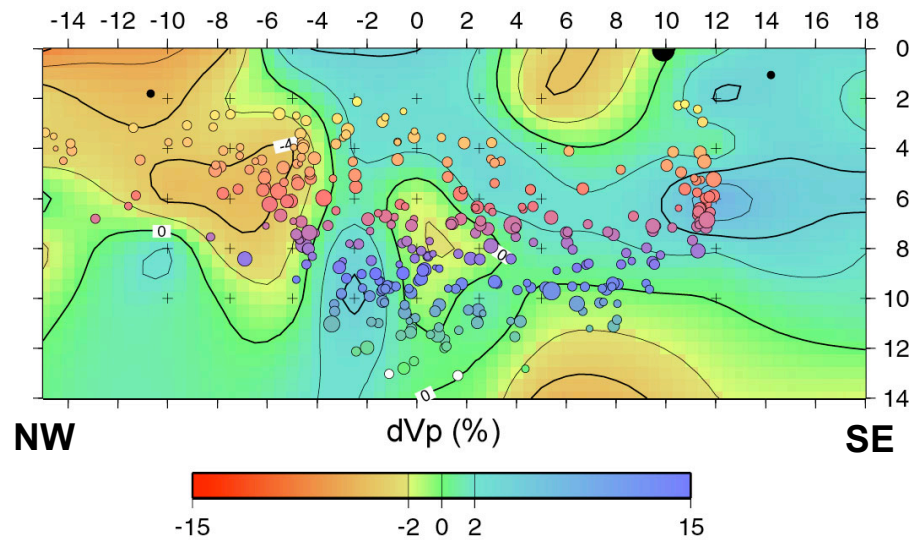
Upper: original structure

Lower: result of RRT

a) Original

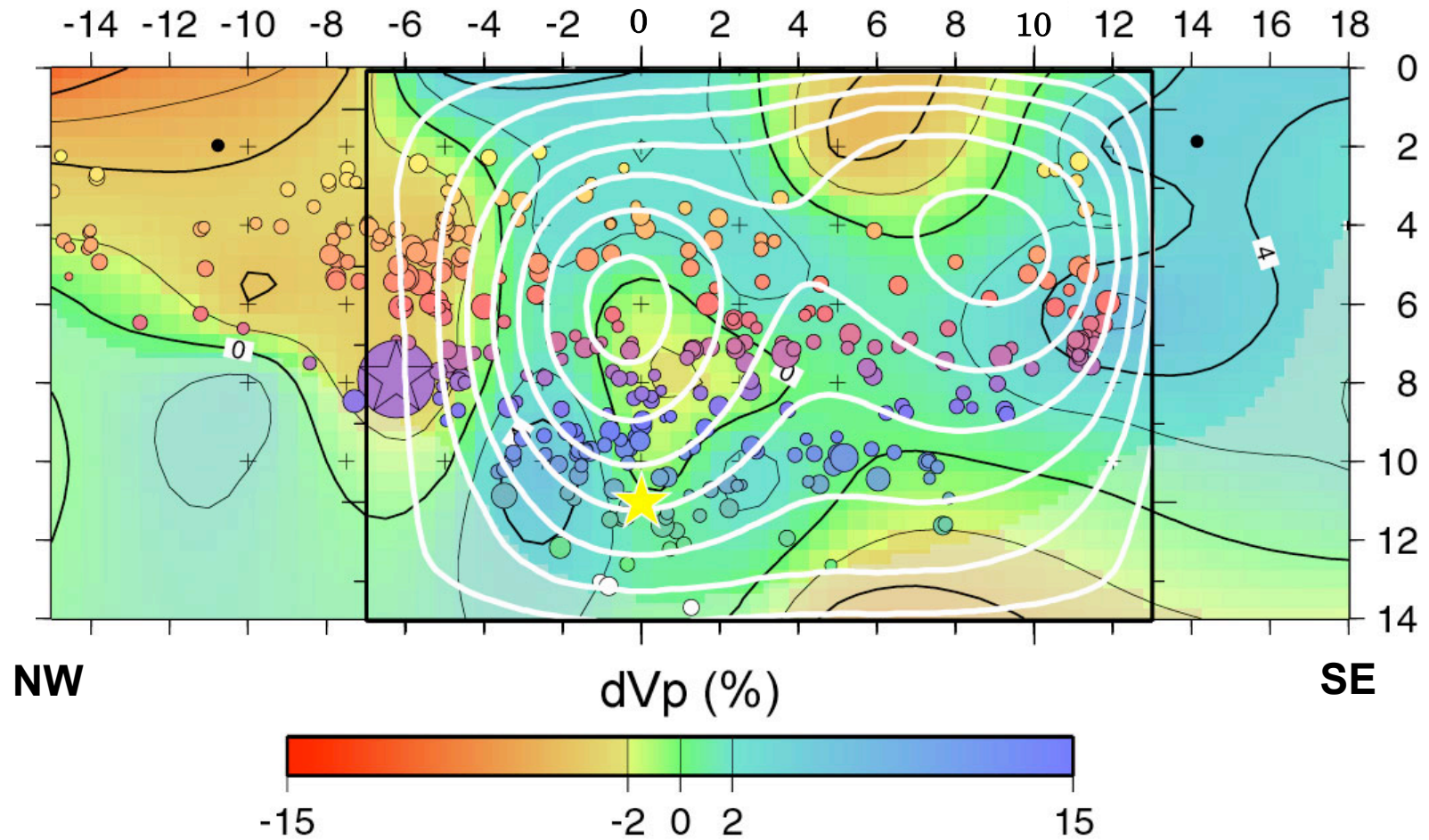


b) RRT





## © dVp & slip distribution along the fault



slip distribution: white contours (Yagi and Kikuchi, 2000)

## © Summary

	fault plane	asperities
1995 Kobe EQ (M7.3)	○ (as a low-V zone)	○ (as high-V areas)
2000 W. Tottori EQ (M7.3)	×	○ (as high-V areas)
2003 N.Miyagi EQ (M6.4)	○ (as a zone of steep velocity change)	○ (as high-V areas)

- provide important information on the cause of asperity formation
- suggest the possibility of imaging asperities of large EQs before their occurrences